and imperfectly done; and for this reason, are necessarily very discouraging in their results. We are to endeavour to save life, and to do all that we can with this view; feeling that the result, although very uncertain, is most frequently a failure; that success is determined by no positive rule, and that the most important measure is *haste*. In fact there is not a minute to be lost, and every moment is precious; the fœtus is like one drowning: it wants oxygen, and this must be supplied as soon as possible. Is the woman dead? then we cannot be in too much of a hurry to deliver the fœtus. Is there any possibility of its being found alive? then we must persevere in our resuscitative efforts until we either restore the child, or are convinced that it is beyond hope. If called in late, open the body, and make sure that the case is, or is not, one of prolonged intra-uterine independence. If there is any possibility of truth in the claims of historical cases, let us test it.

713 LOCUST STREET, Aug. 7, 1879.

ARTICLE VI.

ON CONTUSIONS OF THE CRANIAL BONES. By JOHN A. LIDELL, A.M., M.D., of New York, late Surgeon of Bellevue Hospital, Inspector of the Medical and Hospital Department of the Army of the Potomac, etc. etc.

CONTUSIONS of the osseous tissue are essentially quite analogous to corresponding injuries of the integument or any other soft structure of the body. But, while the bruises of different tissues resemble each other much in general outline, they also differ considerably in important particulars. Thus, in respect to causation, the application of a much greater degree of force is required in order to contuse the hard osseous formations, than that which suffices to contuse the soft structures which invest them externally on the one hand, or are invested by them on the other. The integuments of the head are often severely bruised while the underlying bone escapes all injury. This difference obviously results from the greater solidity and strength of the osseous when compared to that of the soft structures in general. Again, in respect to phenomena, contusion of bone is by no means so constantly attended with ecchymosis as is contusion of the soft parts. Indeed, we but seldom if ever meet with an interstitial extravasation of blood sufficiently copious to constitute what is termed ecchymosis of bone in cases where the osseous tissue is contused, unless the structure is porous or cancellated, as it is in the spongy epiphyses of the long bones, in the short bones, etc. It is probable that ecchymosis does not occur in the compact structure of bone when bruised, because the medullary spaces in that structure are not large enough to hold a sufficient quantity of extravasated blood to produce the characteristic discoloration. But when the cancellous structure of bone happens to get bruised, ecchymosis not unfrequently appears. The writer published two examples thereof in the number of this Journal for July, 1865, pp. 20–23. With regard to consequences, we find in cases of contusion of bone, especially when the compact structure is involved, that the vitality of the bruised osseous tissue is not unfrequently destroyed outright by the contusing force. Such a result is but seldom produced by contusions of the soft parts, excepting those rare instances wherein the integuments are badly bruised by large fragments of exploding shells, or by the impact of cannon balls whose force is almost spent, and those other cases wherein a thin layer of tissue surrounding the track of musket balls is killed by the stroke of these missiles. Moreover, contusions of bone generally prove much more troublesome in their management, tedious in their course, and fatal in their results, than contusions of soft parts. Of 13 cases of this form of injury, involving several different bones, which have been reported by the writer, 5 died and 8 more or less completely recovered. Of those who died, 3 had simple and 2 suppurative osteo-myelitis; in one of the latter mephitic gangrene of bone occurred just before dissolution. In all of them the osseous tissue was inflamed. In all of them death resulted from exhaustion; one of them, however, had well-marked pyæmia, and at the autopsy secondary abscesses were found in the lungs, spleen, and kidneys, but not in the liver. Of those who recovered, 1 had to undergo amputation of the thigh in order to save his life, 1 suffered necrosis of the tibia with exfoliation of nearly all its shaft, and a majority of the remaining 6 cases had painful, protracted, and exhausting suppuration, with exfoliation of dead bone, and considerable constitutional disturbance of a threatening character. Of the 13 cases of contusion of bone referred to above, the femur was the seat of injury in 6, the tibia in 4, the fibula in 1, the ilium in 1, and the parietal in 1 instance. Of those who died, the femur was the bruised bone in 4 instances, and the fibula in 1 instance. In 11 of the 13 cases, the injury was sustained by a long bone, and in each of the 5 fatal cases it was a long bone also that was injured.

The foregoing summary clearly shows how troublesome and dangerous to life contusions of the long bones of the lower extremities have proved to be; but it is probable that contusions of the cranial bones are more dangerous still, although the instance of the parietal mentioned above terminated in recovery, since the organs contained within the cranium are of much greater importance in the economy of life than those which are placed in relation with the long bones of the extremities. We next proceed to the special consideration of contusions of the bones which enter into the formation of the skull.

And firstly, in order to show the relative importance of this traumatic lesion of the head, we may state that the Army Medical Museum at

Washington contains 246 osteological specimens of gunshot injury of the head, and that included among them "are 22 specimens of gunshot contusion of the cranium" (*Circular No.* 6, p. 10). The examples of contusion constitute about one-eleventh part of the whole number. On referring to the published catalogue of this museum we find that most of these specimens of cranial contusion were obtained from cases which proved fatal. Some of them, however, consist of exfoliations of dead bone obtained from cases that terminated in recovery. Moreover, 328 cases of gunshot contusions of the cranial bones are reported in the *Medical and Surgical History of the War of the Rebellion*, and concerning them it may be stated as a near approximation to truth, that 55, or 17 per centum, died, 98, or 30 per centum, were permanently disabled, and 175, or 53 per centum, recovered (Part First, vol. ii. p. 128). We must therefore consider contusions of the cranial bones as injuries of frequent occurrence and dangerous character in military practice. But this kind of injury also occurs not unfrequently in civil life. Thus, Mr. Prescott Hewett states that "specimens of extensive disease, limited to the outer parts of the calvaria, and caused by a simple blow, exist in the museums of the Royal College of Surgeons and of St. George's Hospital." He also refers to a case mentioned by Dr. Abercrombie in which the inner table alone was thus extensively destroyed; likewise to Norris's case, in which "the disease attacked both tables of the whole of the calvaria, and extended even as far as the foramen magnum;" to Drummond's case, as affording "another example of extensive destruction of the vault of the skull, originating in a blow on the head;" and to Saviard's case as the most extraordinary example of the kind on record, since, "two years after a blow on the head, the whole skullcap came bodily away." The same writer also mentions an extraordinary specimen of hypertrophy of the skull resulting from contusion, which is contained in the museum of the Royal College of Surgeons, and says: "In the vault of this skull the bones are in some parts no less than eleven lines in thickness" (Holmes's *System of Surgery*, vol. ii. pp. 248, 249, 2d ed.). Mr. Pott relates a considerable number of cases of contusion of the skull produced by various casualties to which man is exposed in civil life, that had come under his own observation (*Chirurgical Works*, vol. i. pp. 49–107). Our Army Medical Museum contains a specimen that is classified under the head of injuries not caused by gunshot, and consists of "the vault of the cranium from an epileptic subject, showing necrosis in the right frontal eminence, the evident result of an old injury. The necrosed fragment, of the size of a small bean, is not detached, but the line of demarcation is well marked on both tables. Traces of ostitis, really incipient caries, are apparent for an inch around the central portion" (*Catalogue of U. S. Army Medical Museum*, p. 36, Specimen No. 2230). Besides the foregoing, several examples of contusion of the cranial bones not produced by gunshot will either be related or referred to in the following pages. Moreover, most surgeons of experience have doubtless met with cases in which a blow on the head, unattended with fracture, has been followed by exfoliation of the injured part of the skull, or by suppuration of the diploë (suppurative osteo-myelitis), or by caries (ulcerating ostitis), or by some important pathological condition of the encephalon which had its origin in an inflammation of the bruised osseous tissue.[1]

Causes.—Among the more important of the accidents which produce contusion of the cranial bones, we may briefly enumerate the following, namely: The impact of small arms, projectiles, and fragments of shell against the cranial bones, under certain favouring circumstances, blows on the head inflicted with blunt instruments, falls on the head, falling bodies striking the head in their descent, and the kicks of animals against the same part. But, in whatever way the force may be applied to the head, it is necessary, in order for contusion of the osseous tissue to occur, that it should not be so great as to produce solution of continuity or fracture, but still so sudden and violent in its application as to greatly disturb the anatomical relations that naturally exist among the histological elements of which the bone is composed, through a limited space at the place of injury; in other words, the blow must be strong enough to produce a hurtful commotion with crushing or laceration of the bone-corpuscles, the canaliculi, the Haversian canals, the medullary tissue, and the minute bloodvessels belonging to the injured part. In cases where contusion of bone occurs, it is probable that interstitial extravasation of blood almost always occurs, but ecchymosis is not discernible by the unaided eye unless the structure is such that the medullary spaces possess some considerable size, as, for example, they do in the diploë of the cranium, in the spongy tissue of the short bones, and in the epiphyses of the long bones. Hence, the compact osseous structures may be severely bruised without presenting an ecchymosed appearance. In warfare, contusions of the cranial bones are, for the most part, produced by glancing bullets and by those whose force is almost spent. Sometimes, however, they are occasioned by grazing bullets. In cases belonging to the glancing and grazing classes, the missile, if composed of lead, is apt to leave behind it particles of that metal sticking in the bruised osseous tissue.

Consequences of Contusions of the Cranial Bones.—Most of these have already been hinted at, or cursorily mentioned. They pertain either to the injured part of the bone itself, or to the integuments which cover it, or to the structures which lie beneath it; for example, the dura mater, the arachnoid, and the brain-substance. For the purposes of study and description they may be conveniently arranged under the following heads:—

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[1] The experience gathered by our army surgeons during the late war of the Rebellion has added very much to our knowledge of cranial contusions. A free use of this experience, and of the important lessons which it conveys, will be made in the following pages.

1. The bruised portion of bone may be suddenly deprived of vitality at the moment of injury, *i. e.*, it may be killed outright by the blow, and thus *primary necrosis* may be produced.

2. Inflammation of a formative character may be excited in the elementary structures of which the injured bone is composed, and thus induration or eburnation and hypertrophy may result.

3. Inflammation of a suppurative character may be excited in the medullary tissue of the diploë, *i. e.*, suppurative osteo-myelitis of the bruised bone, and from this, pyæmia with secondary abscesses in the lungs, liver, etc., may spring; or thrombosis and pulmonary embolism may occur.

4. Inflammation of a destructive character may be excited in the bruised osseous tissue itself, and osteo-porosis, caries, and inflammatory necrosis may be extensively produced, with corresponding exfoliations of dead bone.

5. The inflammatory process may spread from the bruised bone to the dura mater and cause purulent matter to be deposited between that membrane and the bone; or it may spread still further to the arachnoid and the brain-substance, and thus kindle meningitis or encephalitis that quickly proves fatal.

6. Puffy swellings of the scalp, and sub-pericranial collections of purulent matter may form over the inflamed portions of bruised bone. Also, in the cases belonging to this category, erysipelas of the scalp sometimes supervenes.

7. Protracted inflammation of the contused pericranium, or osseous, or medullary tissues, sometimes follows, and in cases produced by gunshot, the wound may reopen at intervals and suppurate, yet no exfoliation take place. In such instances the patient usually has much pain in the injured part.

1. *Primary Necrosis.*—It happens, not unfrequently, in cases where the cranial bones are contused from the impact of musket balls and other small-arms projectiles, that necrosis or death of the bruised portion of bone is directly occasioned by the stroke of the projectile, without the intervention of the inflammatory or of any other pathological process whatever. In such cases the lesion of bone may, with propriety, be denominated primary necrosis, in order to distinguish it from the secondary forms of necrosis, which always have their origin in inflammatory action or in some pre-existent disease. The following case presents us with an excellent example of this important lesion. The writer watched its progress from day to day with lively interest.

CASE I. *Gunshot Wound of Scalp with Contusion of Right Parietal Bone, Inflicted by a Glancing Bullet; Primary Necrosis and Exfoliation of the Bruised Osseous Tissue; Recovery.*—Henry Abbott, Co. B, 32d Maine Volunteers, aged 21, was wounded in the head by a conoidal musket-shot at the battle of Tolopotomy Creek, Va., May 31, 1864, and

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taken at once to the 2d division hospital of the Ninth Corps. On June [illegible], he was admitted to the Stanton Hospital, at Washington, under the writer's charge. The missile struck the scalp over the right parietal bone, passed downward and forward, making a furrowed wound of the scalp about three inches long and then escaped, denuding the bone and exposing the squamous suture in its course. On careful examination we found that the bone was not broken. It was neither fissured nor depressed. The patient's general condition was excellent. He did not exhibit any cerebral symptoms worth mentioning; bowels soluble. *Treatment.*—Quietude, ice-dressing for the wound, tinct. aconiti radicis, gtts. ij, every three hours, and a spare diet.

June 7. He has diarrhœa with six or eight evacuations in twenty-four hours. Prescribed opium, gr. $\frac{1}{2}$; tannin, gr. j; camphor, grs. ij; to be administered after each passage. In a short time the diarrhœa ceased, and his general health continued good. The wound suppurated and discharged laudable pus. It soon presented a florid, healthy appearance, from the formation of new granulation-tissue; but the portion of the skull exposed at its bottom was observed to remain bare and white, and apparently dead.

July 12. Removed a fragment of necrosed bone about one inch in length by half an inch in breadth. It embraced a part of the squamous suture, and consisted of the outer table and the diploë. It was not stained nor altered in structure by the inflammatory or any other pathological process. The wound was filled with healthy granulations, and the patient still had good health. Prescribed the warm water dressing for the wound in place of the ice-bag.

14*th*. Removed another fragment of necrosed bone about half an inch in length, and corresponding in appearance to that just mentioned. It consisted of the inner table.

17*th*. Health very good; wound almost healed.

18*th*. He left Stanton Hospital, having been transferred to the north.

21*st*. He entered Grant Hospital at Willett's Point, N. Y., whence he was returned to duty on Dec. 21, 1864. The recovery appears to have been complete, as the man's name does not appear on the list of applicants for pension.

This account of the case has been compiled from my own notes, and from the record of it which is given in the *Medical and Surgical History of the War*, at p. 122, vol. ii., Part First.

Comments.—It is worthy of remark that the external table of the skull was necrosed to a much greater extent than the internal table, in this case, and that if the necrosis had been occasioned by fracture, if the fragments of bone which in the end were cast off by exfoliation, had in the beginning been broken off by the impact of the projectile, and separated from the surrounding bone by fissure and depression, just the converse would have obtained; or, in other words, the internal table would have been destroyed to at least an equal, and probably to a much greater extent than the external table. Indeed, the physical properties of the cranium, its density, toughness, and elasticity, are such that in order for an islet of bone to become separated from the surrounding osseous tissue by fracture, it is necessary for it to be driven inward or depressed some distance, and on the subsidence of the fracturing force, it does not rise up again to its original position or level. Moreover, it is obvious, that in order for depression of the skull in its whole thickness to take place in consequence of fracture, the hole in the internal table must be as large, at least, as the corresponding hole in the external table; and when we also consider that the inner table is more brittle than the outer, and that being situated on the internal arched surface of the skull on the side opposite to the place of impact, the fracturing force drives the external table into the skull and the internal table off from the skull, we must expect to find the internal table much more extensively broken than the external table, in all cases where the vault of the cranium is fractured with depression of an islet of bone.

To what cause, other than the direct action of the bullet on the bruised portion of the cranium, can the necrosis of both tables which occurred in this case be reasonably ascribed? We believe that it was not occasioned by fracture for reasons just given, and for the further reason that a most searching examination of the wound showed the continuity of the skull to be unbroken. We also believe that it was not occasioned by destruction of the pericranium and consequent denudation of the bone, because that lesion is for the most part not attended with the exfoliation of any dead osseous tissue whatever, and in the exceptional cases where it does occur, the exfoliated bone consists of thin lamellæ from the external table, but never of the whole thickness of the cranium. It was not produced by inflammation of the osseous tissue itself, nor by inflammation of the diploë, nor by inflammation of the dura mater, because the clinical history of the case clearly shows that destructive inflammation did not, at any time, exist in these parts. Hence, the conviction is forced upon us that the bruised part of the cranium was killed outright by the stroke of the bullet; and we are confirmed in this belief by the appearance which the exfoliations themselves presented when critically examined. They were white, clean, dry, not discoloured externally nor internally, not altered in structure externally nor internally, and looked exactly like broken fragments taken from the bleached cranium of an ordinary skeleton. The following example belongs to the same category as the above:—

CASE II.—John Yetter, private, Co. A, 11th N. J. Vols. aged 21, was wounded near Petersburg, Va., Nov. 10, 1864, by a conoidal ball which lacerated the scalp and contused the anterior part of the left parietal bone. On Nov. 26th he was admitted to Stanton Hospital, at Washington. There was a necrosis of the cranium one-fourth of an inch in diameter. Low diet and gentle purgatives were prescribed, and, as suppuration became established, emollient poultices were applied to the wound. On Dec. 21st the contused portion of bone was found to be loosened by the process of absorption and suppuration. The patient was placed under chloroform, and, through a crucial incision, a piece of the external table of the left parietal bone half an inch in diameter, and a corresponding piece of the internal table of that bone one-fourth of an inch in diameter, were extracted. On the 29th, another small piece of bone, consisting of both tables, was removed from the inferior margin of the wound. Water dressings were applied. The patient made a rapid recovery, without any untoward symptoms; but it was thought inexpedient to return him to active service in the field. He did efficient duty for some months as a nurse in the hospital. When discharged on the general muster out of troops, June 15, 1865, he was in excellent health. His name does not appear on the list of applicants for pension. The fragments of necrosed bone are preserved in the Army Medical Museum, and figured in the *Medical and Surgical History of the War*, Part First, vol. ii. p. 123.

Comments.—In this case, the necrosed part was found to be completely separated and detached from the living bone on Dec. 21, *i. e.* forty-one days after the injury was inflicted. The external table was likewise destroyed much more extensively than the internal. Now when a portion of any cranial bone has been killed by contusion, or suffered primary necrosis, Nature proceeds at once to slowly separate and detach the dead from the living osseous tissue, in order that it may be rendered harmless, and expelled from the system. This object is spontaneously accomplished in a beautiful manner by the occurrence of fungating ostitis, that is, by the transformation of the histological elements of the living osseous tissue where it borders upon the necrosed part, into soft, red, medullary or granulation tissue. The calcareous matter disappears under the local excitement occasioned by the dead bone acting as an irritant, the intercellular or basis-substance softens, the bone-corpuscles change into rapidly proliferating medullary cells, the blood-supply is largely augmented, and thus the hard osseous becomes transformed into soft, red medullary or granulation tissue around the necrosed fragment (Virchow). Thus, after the lapse of some weeks, the dead remains connected with the living part of the bone only by an intervening lamina of delicate fleshy granulations formed at the expense of the living osseous tissue. Thus, it happens, that when we examine the dry specimens illustrating necrosis, which are preserved in pathological cabinets, we generally find the cavity to be larger than the necrosed fragments which come from or belong within it. This detachment of the dead from the living bone was completed in the case of Henry Abbott in about six weeks, and in the case just related in about six weeks also. On extracting the loosened necrosed fragment, we usually find its bed covered over with soft florid granulations, which bleed readily and freely on very slight injury; and the gap left in the bone after its removal usually becomes quickly filled up with them.

The following is likewise an example of primary necrosis involving both tables of the skull in consequence of gunshot injury.

CASE III.—John McGuire, private, Co. G, 65th N. Y. Vols. Gunshot contusion of the frontal bone. Antietam, Sept. 17, 1862. Treated in Carver Hospital at Washington. Exfoliation of both tables of the os frontis resulted, and he suffered from neuralgia. He was discharged from service on Oct. 21, 1862, and his name does not appear on the pension rolls. (*Loc. cit.*, p. 104.)

Comments.—The fact that exfoliation of the dead bone was completed in this case within a period of less than five weeks, and that the patient's recovery remained so satisfactory that he did not apply for a pension confirms the opinion that in this case also, the bruised part of the frontal bone was killed outright by the stroke of the bullet. Had this necrosis been consecutive to traumatic inflammation of bone or periosteum, or medullary tissue, the sequestration and discharge of the dead osseous tissue could not by any possibility have been successfully accomplished in this brief period. No, this necrosis could not have been occasioned by any agency other than the blow received from the bullet. Nor is it difficult to perceive how such a blow may destroy the vitality of bony structures, when we take into account the elementary composition of osseous tissue. This kind of injury may instantaneously and completely arrest the nutrition of the bruised portion of bone by stopping the flow into and through it of the nutritive juices and nutritive material, in consequence of the crushing of bone-corpuscles and canaliculi, and the disruption of Haversian canals, and in consequence of the laceration of capillary bloodvessels contained in the Haversian canals and in the medullary spaces, with which such a bullet-stroke upon the skull is attended, and that, too, without the occurrence of any solution of continuity of the cranium that could properly be termed a fracture. Thus the bruised portion of bone perishes for want of nourishment on the part of its basis-substance and cell-structures.

Again, contusions of the cranial bones, which in respect to severity, fall short of necrosing the whole thickness of the skull, may kill the external table only, or some of the exterior laminæ of that table, at the place of injury; and, generally when the whole thickness of the skull is killed in this way, the external table is much more extensively destroyed than the internal table, as we have already shown. The lighter grades of cranial contusion are sometimes followed by exfoliation of the exterior laminæ whose vitality has been destroyed, not indirectly by detachment of the pericranium, but directly by the contusing force itself. Examples of this sort are not unfrequently produced by blows on the head, and by the kicks of animals on the same part. This form of primary necrosis is also not unfrequently produced in the skull by the impact of gunshot projectiles. The next nine cases are examples in point.

CASE IV.—Wm. McNichols, private, Co. K, 69th Penn. Vols. aged 28. Contusion of the left parietal by a fragment of shell, which lacerated the scalp for three inches or more, Gettysburg, July 2d, 1863. Treated at Mower Hospital, Philadelphia. On August 14th, an exfoliation of the outer table was removed. The patient recovered and was returned to duty on Dec. 16th. His name is not on the pension rolls. (*Loc. cit.*, p. 104.)

CASE V.—Thomas Maxwell, private, Co. K, 5th Michigan Vols., received at the battle of Fredericksburg, Va., December 13, 1862, a gunshot injury of the right side of the cranium, anterior portion. He was, on December 16th, admitted to the Third Division Hospital at Alexandria. A portion of the outer table exfoliated; otherwise the case progressed favourably, and the patient was returned to duty on May 29, 1863. His name does not appear on the pension list. (*Loc. cit.*, p. 104.)

The next patient was a Confederate soldier, who was treated in the Confederate Hospital at Farmville, Va.:—

CASE VI.—R. Duggins, private, Co. C, 11th South Carolina Regiment, received on June 18, 1864, a gunshot contusion of the left parietal bone. He was admitted to the Confederate Hospital at Farmville, Va., on June 21st. The external table of the parietal exfoliated; otherwise the case did well, and the patient was furloughed on July 8th for sixty days. (*Loc. cit.*, p. 103.)

The patient in the following case was also a Confederate soldier:—

CASE VII.—W. A. Lipscomb, sergeant, Co. C, 5th South Carolina Regiment, was admitted on June 23, 1864, to the Confederate Hospital at Farmville, Va., with a gunshot injury of the right supraorbital region. Gradual exfoliation of the external table followed. The patient was furloughed on July 8th. (*Loc. cit.*, p. 104.)

The next case was likewise treated in the Confederate Hospital at Farmville, Va.:—

CASE VIII.—W. S. Solomon, private, Co. G, 66th North Carolina Regiment, was, on June 20, 1864, admitted to the Confederate Hospital at Farmville, Va., with a gunshot injury of the frontal bone, received on June 18th. Gradual exfoliation of the outer table took place, but the patient did well, and was, on July 8th, furloughed. (*Loc. cit.*, p. 104.)

In the following case the patient was a Confederate officer, who was treated in the Confederate Hospital No. 10, at Richmond, Va.:—

CASE IX.—B. M. Whitmer, captain, Co. G, 3d South Carolina Battalion, received, at the battle of Gettysburg, July 2d, 1863, a gunshot scalp-wound, with contusion of the cranium. He was admitted to the Confederate Hospital, No. 10, Richmond, Va. Exfoliation of the external table took place. Captain Whitmer was furloughed on July 20th. (*Loc. cit.*, p. 105.)

The following case was in the Confederate Hospital at Farmville, Va.:—

CASE X.—J. P. Wilson, lieutenant, Co. B, 9th Virginia Regiment, received, at the battle of Spottsylvania Court House, Va., May 10th, 1864, a gunshot injury of the left parietal bone. The wound of the scalp was about two inches long. He was, on May 24th, admitted to the Confederate Hospital at Farmville, Va. An exfoliation of the bone took place, otherwise the case progressed favourably, and the patient was furloughed on July 1st. He was readmitted on October 1st, suffering from acute dysentery and icterus, and returned to duty on October 29th. The injury of the head gave no further trouble. (*Loc. cit.*, p. 105.)

The exfoliation may be limited to a thin plate of the external table, as it was in the following instance:—

CASE XI.—Franklin Tree, private, Co. A, 20th Maine Volunteers. Contusion and denudation of the vault of the skull for one inch by a musket ball, Gettysburg, July 3d, 1863. Treated at Seminary and Satterlee Hospitals. A scale of bone exfoliated. The wound then healed, and the man was returned to duty October 23d. His name is not on the pension rolls. (*Loc. cit.*, p. 105.)

The following is an example of contusion and primary necrosis of the skull produced by a buckshot. Some plates of the external table exfoliated.

CASE XII.—Albert Fauck, private, Co. K, 94th Pennsylvania Volunteers, aged 20, was wounded in a skirmish near the Rappahannock by a buckshot, which entered the scalp over the vertex of the cranium, and lodged near the skull. The missile was extracted on the same day. On September 1st, 1862, he was admitted to the Camden Street Hospital, at Baltimore. Some slight exfoliation, not involving the entire thickness of the outer table, took place; then the wound healed kindly, and, on October 11th, the patient was sent to the Convalescent Camp at Fort McHenry for duty. His name does not appear on the pension rolls. (*Loc. cit.*, p. 103.)

Comments.—Primary necrosis results so frequently from gunshot contusions of the skull that additional examples belonging to the same category might readily be adduced from the same sources, but further cumulative evidence on this subject seems unnecessary in this connection. We may, however, with propriety remark that, of the foregoing twelve cases wherein necrosis of the cranium was produced by the stroke of gunshot projectiles, all terminated favourably. The dead portions of bone exfoliated, and the patients, doing well in other respects, usually made in the course of three or four months a good recovery. The histories of the foregoing cases also show that the primary necrosis of the skull thus produced by contusion, is in healthy subjects, and under favourable circumstances for treatment, etc., not only comparatively free from danger to life, but also not attended with much pain or other distressing phenomena. The fungating ostitis which separates the dead from the living bone is not, *per se*, a painful proceeding. It is a purely conservative process, instituted and carried on in such cases for the purpose of protecting the living parts from the deleterious effects of the dead bone itself and of the suppuration with which necrosis is always attended.

But, in unhealthy subjects, and in patients whose hygienic surroundings are bad, or who receive, perhaps unavoidably, inadequate, neglectful, or injurious treatment, primary necrosis of the cranium thus produced by contusion does not always pursue this favourable course to a successful issue. Instead thereof, a destructive inflammation may be lighted up in the contiguous soft parts, attended with great pain and much suppuration; or the inflammatory process in an acute form may be kindled in the surrounding osseous tissue, and speedily produce inflammatory necrosis of some considerable part of the bone which had not suffered from the original injury; or the inflammatory process may spread inward to the membranes of the brain, and induce meningitis, followed speedily by death, with symptoms of compression of the brain; and, in occasional instances, suppurative inflammation having been excited in the medullary tissue of the diploë, pyæmia occurs, and death results therefrom, long ere the process of exfoliation is completed.

2. *Suppurative Inflammation of the Diploë, or Cranial Osteo-Myelitis, resulting from Contusion of the Skull.*—The effects of blows and other kinds of injury, which simply contuse the cranial bones, are not restricted to the pericranium and the compact osseous tissue thereof. The medullary tissue of the diploë, of the Haversian canals, and of the medullary spaces in general, belonging to the injured portion of bone, also gets bruised at the same time, and in the following manner: The impulse of the blow, or other kind of injury which occasions the contusion, extends to all the layers of tissue which enter into the composition of the injured bone considered as a whole, namely, the pericranium, the external table, the diploë with its cancelli full of medullary tissue, and the internal table, and suddenly produces in these several layers more or less strong vibrations which are not rhythmical or harmonious in form, but, on the contrary, are jarring or discordant, since these several structures differ very much in respect to their thickness, toughness, elasticity, and density; and, in the *mêlée* thus engendered, the soft medullary tissue belonging to the diploë, to the Haversian canals, and to the medullary spaces in general, suffers most of all, for it is highly vascular, very rich in cell-formations, and destitute of any protecting frame-work of connective tissue. Hence, the inflammatory processes pertaining to contusions of the cranial bones have, for the most part, their starting-point in the medullary tissue. If the injury be slight, and the subject otherwise healthy, the medullary inflammation is formative in character, and results in induration or eburnation of the affected bone, which, however, is apt to be most strongly marked in the external table; but, if the injury be severe, or the subject unhealthy, the medullary inflammation is suppurative in character, and leads to the filling up of the cancelli of the diploë and the other medullary spaces with purulent matter. The transformation of the red marrow of the skull, under the stimulus of inflammatory irritation, into pus, is attended with the following phenomena: From afflux of blood it swells up and becomes redder still, the free medullary cells, already granular, multiply themselves with very great rapidity and become more granular still, while, at the same time, the intercellular substance softens and soon liquefies: the descendants of the preexisting marrow cells thus become converted into pus-corpuscles, and the intercellular or basis-substance into liquor puris, or the liquid intercellular material of purulent matter. The following case briefly presents us with an illustrative example.

CASE XIII. *Gunshot Contusion of the Os Frontis; Cephalic Symptoms; Coma; Death; Autopsy; Osteo-myelitis and Osteo-porosis of Injured Part; Meningitis and Cerebral Abscess.*—Ethan A. Crane, musician, Co. K, 44th New York Volunteers, was wounded at the battle of Cold Harbor, Va., June 3d, 1864, by a conoidal musket-ball, which struck the frontal bone on the right side near the median line and glanced, apparently causing only a flesh wound; the bone was barely bruised. He was admitted to the Fifth Corps Hospital, and, on June 10th, was sent to the Carver Hospital at Washington. The case progressed favourably until June 20th, when grave cephalic symptoms appeared. The patient became comatose within eight hours, and died on June 22d from cerebral complications. The *autopsy* revealed a large abscess in the right anterior lobe of the cerebrum, with meningitis, beneath the seat of injury. The external table of the bone was slightly discoloured and cribriform, while the internal table presented a faint attempt at the formation of a circumscribed area of the effects of ostitis. The diploë was found of a dark yellowish-gray colour, as in cases of osteo-myelitis in the heads of long bones. The pathological specimen is preserved in the Army Medical Museum. (*U. S. Sanitary Commission Memoirs*, First Surgical vol., pp. 317, 318; also *Med. and Surg. History of the War of the Rebellion*, Part First, vol. ii. p. 112.)

Comments.—This patient died on the nineteenth day after the wound was inflicted. The cause of death was meningitis and cerebral abscess, which had resulted from spreading of the inflammatory process previously kindled in the cranial walls by gunshot contusion to the contiguous membranes and substance of the brain. The progress of these cerebral complications toward a fatal issue was very rapid, for coma was developed within eight hours, and death occurred on the second day after the appearance of the first adverse symptoms. On examining *post mortem* the affected parts, the products of inflammation of the membranes and substance of the brain were found beneath the site of injury. Moreover, the bruised portion of the os frontis was found to be inflamed all the way through. The external table, the diploë, and the internal table presented certain alterations in structure and appearance which spring solely from inflammatory action. The medullary tissue of the diploë was suppurating, the compact tissue of the external table was discoloured and cribriform or porous, and the dense tissue of the internal table was beginning to be necrosed; or, in other words, the medullary tissue of the diploë was already in the last stage of the inflammatory process, while the laminæ belonging to the external and internal tables were yet in the first stages of the same process. The conclusion is irresistible that the traumatic inflammation, which was kindled in the bruised portion of the os frontis in this case, had its starting point in the medullary tissue of the diploë, and spread from it to the calcified tissues of the contiguous parts of both tables. But how do we know that the medullary tissue was undergoing suppuration in this case? some may ask. We state in reply, *firstly*, that we are not acquainted with any way in which the deep-red medullary tissue of the diploë can acquire a dark yellowish-gray colour, except by its conversion, more or less complete, into pus, through the agency of the inflammatory process; and, *secondly*, microscopical examinations of the cancellous structure of the epiphyses of long bones in strictly analogous cases, *i. e.*, cases of inflammatory disorder of this structure wherein the deep-red marrow has also become changed to a dark yellowish-gray hue, have already shown that such change was due to the metamorphosis of red medullary tissue into purulent matter. The writer has repeatedly witnessed such results on examining microscopically such specimens, and he has reported at least one example belonging to this category, together with an excellent chromo-lithograph illustrating the same, in the *U. S. Sanitary Commission Memoirs*, First Surgical vol., pp. 431, 432, 433, and pl. ix. The part figured in the plate consists of the head and a portion of the shaft of the left os brachii, or rather of the surface of a longitudinal section thereof. The microscopical examination of the cancellous structure of the head of the bone is reported as follows: A specimen taken from the midst of the gray surface of the section, and examined under No. 5, objective, and No. 1, eye-piece of Nachet, was found to contain a large quantity of granular matter, the débris of decomposed pus-corpuscles, with here and there a pus-corpuscle itself. Occasionally a medullary cell also was seen; such cells were granular; their nuclei were large and granular also.

A specimen taken from one of the large cancelli on the border of the gray surface where it joins upon the red, contained a number of fat vesicles, with a large quantity of free oil in the form of very minute globules.

On making a thin transverse section of the compact tissue of the bone, and examining it with a hand-glass, the Haversian canals were seen to be enormously enlarged, especially near the periphery of the bone (circumferential laminæ). In this situation they were so much enlarged as to be easily seen with the unaided eye. These enlarged medullary spaces were stained with the colouring matter of blood (*op. cit.*, p. 433). The next case is, in many respects, similar to the last, while in other respects it is quite dissimilar.

Case XIV. *Gunshot Contusion of Os Frontis; Cerebral Symptoms; Trephining; Puncturing a Cerebral Abscess; Death; Autopsy; Diploë Carious; Cranial Osteo-myelitis, Osteo-porosis, and Inflammatory Necrosis; No direct connection between the Cerebral Abscess and the Diseased Bone.*—Samuel Altman, private, Co. A, Fiftieth Georgia Regiment, was wounded at the battle of Antietam, September 17, 1862, by a musket ball, which laid bare the os frontis to the extent of two inches in length by three-fourths of an inch in width, without depressing or fracturing the bone. He was admitted into the Convalescent Hospital, Philadelphia, September 27th. The wound granulated rapidly, and the patient was apparently doing well, exhibiting no symptoms of injury of the brain, except that he was sullen and stupid, which was attributed to other causes. On October 6th he complained of headache, chills, and fever, and, on the 8th, cerebral symptoms appeared, and rapidly increased until the 11th, when the indications of approaching dissolution were unmistakable, the pulse being rapid and small, the skin cold, the pupils natural but insensible to light. The patient was etherized, and the operation of trephining performed, in order to evacuate a cerebral abscess that was supposed to exist.

A button of bone was removed, and the brain punctured, giving exit to six or seven ounces of sero-purulent fluid, containing fragments of broken-down brain-tissue, with such force as to spurt three feet from the patient. The effect of the operation was favourable; the skin became warm, the pulse gained strength and was less rapid, the breathing easier, and the patient appeared in every way better. The wound was closed and stimulants administered, but exhaustion followed, and death occurred on October 11th. At the *autopsy*, it was found that the ball had struck the os frontis on the left side, near the coronal suture, two and one-half inches from the middle line of the cranium. The inner table was necrosed over an irregularly circular space, one and one-half inch in diameter, the diploë between the outer and inner tables at this point being carious. There was an abscess, with greenish indurated walls, three inches in diameter, in the anterior lobe of the left cerebral hemisphere. It had burst, and its contents filled the cavities of the brain. There was no pus under the diseased bone on the surface of the brain, and there did not appear to be any immediate connection between the diseased bone and the cerebral abscess. The pathological specimen is preserved in the Army Medical Museum, at Washington. It shows the vault of the cranium, with the disk in place. The internal table is cribriform. The outer table is porous, and discoloured to a slight degree. The pathological specimen is also figured in the *Medical and Surgical History of the War*, Part First, vol. ii. p. 123.

Comments.—The carious state of the diploë mentioned above doubtless signifies that the medullary tissue of the diploë had been destroyed through the transformation thereof into purulent matter, by inflammatory action, and that the cancelli of the diploë were filled with this matter, or, in other words, that cranial osteo-myelitis in a far advanced stage was present. The porous condition which was found in the outer table, and the cribriform condition of the inner table, show that these parts also were inflamed, and that the inflammatory process was of a more recent date in them than the corresponding process in the diploë. This case, then, like the last, is an instance where gunshot contusion of the os frontis occasioned destructive inflammation in the medullary tissue of the diploë, which spread therefrom to the contiguous osseous tissue, producing abnormal porosity and necrosis therein. Again, this man survived his injuries twenty-four days, while, in the preceding case, death occurred on the nineteenth day after the injuries were inflicted. We are, therefore, not surprised to find that the inflammatory process in the bruised bone, as disclosed by the autopsy, was somewhat further advanced in its course, in this, than it was in the preceding case.

But this case *differs* from the preceding in some important particulars. For example, in this case death resulted from an immense abscess of the cerebrum, which had not grown out of, and was in no way connected with, the morbid process in the bruised portion of the skull; while, in the preceding case, death resulted from meningitis and cerebral abscess which had been produced by spreading of the inflammatory process from the contused portion of the skull into the membranes and substance of the brain. It is, however, highly probable that the cerebral inflammation, which led to the fatal result in this case, was traumatic in respect to origin; and that it was produced by injury done to the brain-substance by the same projectile that bruised the frontal bone. Moreover, the sullenness of manner and stupidity of appearance which this patient was observed to exhibit prior to the advent of alarming symptoms, support this view of his case, since these phenomena were most probably due to concussion of the brain, and his history furnishes us with no occasion on which such concussion could have been produced, except the time when his frontal bone was contused by a musket ball.

The presence of a cerebral abscess as the cause of the alarming symptoms was so strongly suspected, that the cranium was penetrated by trephining at the site of injury, and the brain punctured, giving exit thereby to six or seven ounces of sero-purulent matter containing fragments of broken-down cerebral tissue, which escaped with great force from the opening in the skull. This operation prolonged the patient's life somewhat, but did not avert the fatal issue of his case.

CASE XV. *Gunshot Contusion of Os Frontis; Headache; Chills and Vomiting; Trephining; Cranial Osteo-myelitis and Osteo-porosis were found; Delirium; Trombosis of Frontal and Orbital Veins. Coma; Death.*—William Attig, private, Co. A, 49th Penna. Vols., aged 25, was wounded near Rappahannock Station, Va., November 7, 1863, by a conoidal musket-ball, which struck his forehead near the left frontal eminence, denuding the bone of its periosteum for about an inch. He was brought to Washington, and admitted to Harewood Hospital on the 9th, complaining of slight headache over the region of the eyes. His pulse was normal, and his appetite poor. On the 17th, chills, with vomiting, supervened, and the eyes became lachrymose. These symptoms continued until the 19th, when he was anæsthetized, the skull laid bare by a crucial incision through the scalp, and pus was found issuing through the denuded bone. The trephine was then applied near the left frontal eminence, giving exit to a small quantity of pus, which was found between the dura mater and the skull. After the operation the patient became free from pain. During the night of the 20th he became delirious, and lay in a stupor nearly all the time, but answered questions correctly. The next morning, the forehead and right eyelids were œdematous; the pulse was seventy-five and feeble. On the 23d, low muttering delirium followed, coma ensued, the alvine evacuations became involuntary, and his breathing stertorous. On the 24th, at 11 A.M., the dura mater was incised, giving exit to a small quantity of pus, but no relief was afforded, and death occurred two hours afterwards. The pathological specimen is preserved in the Army Medical Museum. A figure of it is also presented in the *Medical and Surgical History of the War*, Part First, vol. ii. p. 124.

Comments.—The patient in this case complained of pain located in the injured bone when admitted to hospital, on the second day after he had sustained a gunshot contusion of the os frontis, which stripped off the pericranium over a considerable space. Eight days later, chills, vomiting, and head symptoms appeared, which continued for two days, when, on baring the contused bone by a crucial incision through the scalp, pus was found oozing through the portion thereof that had been denuded by the projectile. The operation of trephining was then performed which liberated a small quantity of pus that was confined between the dura mater and the skull, and gave complete relief from pain. Whence came the purulent matter which was found oozing through the external wound at the site of injury? In all probability, it came from the diploë, and had its origin in suppurative inflammation of the medullary tissue thereof, which had been called into being by the stroke of the missile. On the second day after the operation, the forehead and right eyelids became œdematous, no doubt in consequence of the frontal and orbital veins having become obstructed with coagula spontaneously formed therein, *i. e.*, in consequence of thrombosis of these veins. On the following day symptoms of compression of the brain appeared; and, one day later still, the dura mater was incised with a view to relieve the cerebrum from compression, but without avail, and two hours afterwards death occurred. This man survived his injuries only seventeen days; and his death was, in reality, due to spreading of the inflammatory process from the bruised bone to the membranes and substance of the brain. The first step, however, in the morbid process which thus eventuated in his death, was the suppurative inflammation of the medullary tissue of the diploë, which was started by the stroke of the musket ball on the frontal bone. Thence, the inflammatory process extended itself to the tables of the skull, producing a porous or spongy condition thereof; and, finally, to the meninges and brain-substance, with a fatal result, as stated above. The next case also belongs to the same category as the last.

CASE XVI. *Gunshot Contusion of Right Parietal; Convulsions and Coma on the sixteenth day; Trephining; Death; Autopsy; Suppurative Osteo-myelitis and Diffuse Meningitis.*—Joseph Resinger, private, Co. E, 151st N. Y. Vols., aged 21, received at the demonstration on Mine Run, Va., Nov. 27th, 1863, a gunshot wound of the scalp, over the right parietal bone. He was brought to Fairfax Seminary Hospital. There was no cerebral disturbance at the time of admission. The pericranium was not removed, and it was hoped that the skull had escaped uninjured. He was allowed to be up and about the wards, and no symptoms of any grave injury appeared until December 13th, when he was suddenly seized, while seated at the supper table, with convulsions, and immediately became unconscious. He was taken to his bed, the skull was bared by incision at the seat of injury, and the trephine applied. Pus was found immediately beneath the bone, and it also oozed from the diploë. It was thought expedient to make five perforations with the trephine, in order to remove the diseased bone, and to give free exit to pus. The convulsions did not recur, but the comatose condition continued, and the case terminated fatally twelve hours after the operation. The *autopsy* revealed diffuse inflammation of the arachnoid and of the dura mater. The dura mater was not incised, as it did not bulge into the perforations made with the trephine. The pus proceeded only from the diploë and from between the dura mater and the skull. The specimen is preserved in the Army Medical Museum, at Washington, and is figured in the *Medical and Surgical History of the War*, Part First, vol. ii. p. 125.

Comments.—This man also died on the seventeenth day after his wound was inflicted. The cause of his death too was compression of the brain occasioned by the products of diffuse inflammation of the dura mater and arachnoid. The meningitis itself resulted from an extension of the inflammatory process from the diploë to the inner table of the skull, to the dura mater, and to the parietal and visceral arachnoid. The morbid state of the diploë, with pus oozing from its cancelli, was due to suppurative inflammation of its medullary tissue which had resulted from injury done to that tissue by a gunshot projectile which bruised that portion of the skull. Moreover, meningitis thus induced by spreading of the inflammatory process from the diploë to the membranes of the brain, was one of the most common causes of death after gunshot contusions of the cranial bones among our soldiers during the late war.

CASE XVII. *Contusion of the Right Parietal Bone occasioned by falling on the head; Puffy Swelling and Abscess of the Scalp; Convulsions; Coma; Death. Autopsy: Extensive Necrosis; Recent Meningitis; Large Cerebral Abscess; Cranial Osteo-myelitis (chronic).*—Corporal Joseph B. Hefler, Co. D, 7th Iowa Cavalry, aged 25, was thrown from his horse at Louisville, Ky., April 15th, 1864, falling between his own horse and that of a comrade, and striking somewhere upon his head. His injury was considered to be of a slight character, although he was badly stunned, and he rejoined his company in a day or two afterward. But he suffered from constant headache until about the 29th of August, when a puffy swelling of the scalp appeared over the right parietal bone. An abscess formed which continued to enlarge until it was opened on November 30th. The patient was then transferred to the hospital at Madison, Indiana. On admission there on December 1st, the abscess was exceedingly painful, his pulse was 90, skin dry and hot, tongue coated, and bowels constipated.

Treatment.—A free incision was made in the diseased scalp; the right parietal bone was exposed and found denuded for the space of six square inches, and in a necrosed state. The wound was dressed with cataplasms of pulvis ulmi; stimulants and a nutritious diet were ordered. On December 21st, the patient being under chloroform, the opening in the scalp was enlarged and the flaps reflected, with a view to remove the necrosed bone; but upon examination it did not seem to be sufficiently separated to justify operative interference. On January 1st, 1865, brain-symptoms of a very marked character suddenly appeared. He had convulsions recurring in rapid succession for two days, and slight coma, which, however, did not become profound until a short time before death. His mental powers were but little impaired, and he was able to converse intelligently up to a few hours before death, which occurred on January 12th. At the *autopsy* a large abscess was found in the right hemisphere of the cerebrum, communicating with the lateral ventricle, and containing several ounces of offensive pus. There were evidences of recent inflammation of the cerebellum and of the meninges of the brain. The right parietal bone was extensively necrosed and perforated in several places at the seat of injury. The walls of the cranium were observed to be very thin. The thoracic and abdominal viscera were normal.

The foregoing account of this most instructive case has been drawn up partly from original notes thereof received by the writer through the hands of Dr. Elisha Harris, and partly from the record of it contained in the *Medical and Surgical History of the War*, Part First, vol. ii. p. 41, where it is reported under the head of "Miscellaneous Injuries."

Comments.—The cranial contusion in the case just related was occasioned, not by a gunshot projectile, but by falling on the head from on horseback. The man also sustained severe concussion of the brain, and was insensible when picked up. However, he soon recovered and returned to duty, and hence his injuries were thought to be but slight. Nevertheless, he afterwards suffered constantly from pain in the head until about the end of August, four and one-half months after the injuries were received, when a puffy swelling of the scalp appeared over the right parietal bone. The interpretation of these symptoms by means of the light thrown upon them by subsequent events in the history of the case, is as follows: The right parietal bone was contused by the fall, and thus traumatic inflammation of a suppurative character was excited in the medullary tissue of the diploë belonging to the injured part of the bone, whereby this tissue was converted into purulent matter and destroyed. Meanwhile the inflammatory process spread over the contiguous osseous laminæ of both tables, reducing them to a porous or spongy condition, and likewise causing several perforations of the bone through which the purulent matter escaped from the suppurating diploë into the pericranial tissue, thereby causing first a puffy swelling, and subsequently an abscess of the scalp which enlarged continually until it was opened by incision some three months afterwards. The headache ceased as soon as the imprisoned matter escaped.[1] Then, as time wore away, the right parietal bone suffered also from necrosis. On December 1st, about three months after the puffy swelling of the scalp made its appearance, the abscess of the scalp which succeeded it was freely incised; the underlying bone was laid bare thereby, and shown to be denuded and *necrosed to the immense extent of six square inches.* Six weeks later still death occurred from compression of the brain which was occasioned by the inflammatory products that had been formed in consequence of the spreading of the inflammatory process from the injured bone to the membranes and substance of the brain.

The porous, spongy, cribriform, or rarefied condition of the compact laminæ of the cranial tables already several times mentioned as a consequence of ostitis is produced in the following way: The inflammatory irritation spreads from the medullary tissue contained in the cancelli and the larger canals of Havers, unto the osseous laminæ which lie in contact with that tissue, and produces in those laminæ softening of the intercellular substance with disappearance of the calcareous salts, and conversion of the bone-cells into marrow-corpuscles, or, in other words, it transforms the contiguous osseous laminæ into medullary tissue. The effect of this kind of inflammatory transformation of the osseous tissue is to destroy some of the bony partitions between the cancelli, to diminish the thickness of all that are subjected to its influence, and thus to increase the size of the cancelli, and the medullary spaces, and the Haversian canals.

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[1] There is good reason for believing that the operation of trephining the external table of the skull, as recommended by Abernethy, so as to secure a free outlet of pus from the diploë, had it been performed at this time, *i. e.*, at the end of August, would have arrested the disease at this stage, and thus have saved the patient. For further information on this point read the last pages of this article.

In the case just related the contused bone was found to have been perforated in several places by the purulent matter that was imprisoned in the diploë, while it was striving to escape from confinement therein. Suppuration here, like all changes attended by an over-production of corpuscular elements, demands space, and sometimes a great deal of space; and the mechanical force exerted by the repeated division and multiplication of the cells is too great to be resisted by the tension of the blood in the vessels when the two forces are opposed to each other in a confined space which is at once inadequate and incapable of expansion. In this way suppuration of the diploë gives rise to the most manifold and profound disturbances of nutrition, especially in the external table, for it derives most of its blood-supply from vessels that run in the diploë.

In the case just related the contused bone was also found to have become extensively necrosed. This morbid condition of the bone was produced in the following manner: As the destructive inflammation of the medullary tissue of the diploë advanced, the inflammatory process which had spread from it to the circumjacent osseous tissue increased in severity, until the capillaries of the Haversian canals became strangled, as it were, by the products of the osseous inflammation itself compressing them against the unyielding walls of these canals. Arrest of circulation, arrest of nutrition, and death or necrosis of the large section of the right parietal bone thus deprived of blood was the necessary consequence thereof. This necrosis was due to ostitis which had itself been acquired from inflammation of the contiguous medullary tissue, and was, therefore, secondary in character. Primary ostitis is a disorder of extremely rare occurrence. As a secondary disorder, however, it is very frequently met with. It follows both medullitis and periostitis, but the former much oftener than the latter. Secondary ostitis in its mildest form leads to the porous or spongy condition of bone above described, in a severer form the newly made granulation-tissue suppurates, and then we have ulceration and perhaps perforation of bone, or caries, while in its severest form it produces necrosis in the way just shown.

The next case is an example of gunshot contusion of the cranium wherein *pyæmia* supervened with a fatal result. It is reported in the *Medical and Surgical History of the War of the Rebellion* (Part First, vol. ii. p. 84) under the head of "Gunshot Wounds of the Scalp."

Nevertheless, the missile bruised the cranial vault in its passage; and the appearances found on *post-mortem* examination showed that the injury of the bone was of much greater importance than the lesion of the scalp.

Case XVIII.—Private George Gold, Co. I, 155th Penn. Vols., aged 23, was admitted to Harewood Hospital on Oct. 7th, 1864. He had been wounded at Poplar Grove Church, on Sept. 30th, by a musket ball, which struck the scalp, passing from before backwards, tearing up a portion about three inches in length by one inch in breadth, laying bare the skull and denuding it of pericranium for the space of three inches in length and one inch in breadth, through the middle of which the sagittal suture passed, meeting the coronal at the anterior border. The patient was carefully watched for symptoms indicative of cerebral or meningeal inflammation, but none were manifested up to the moment of his death, unless a slight drowsiness, which, at the time, was attributed to the administration of eight grains of Dover's powder, may be so regarded. He was up and about the ward, complaining of nothing except the wound in the scalp, and receiving no treatment except simple dressings, until the morning of Oct. 18th, when he spoke of a slight pain in the left side of the chest, over the lower lobe of the lung. There was some dulness on percussion over the part complained of, but no marked physical signs of inflammatory mischief. On Oct. 19th, the patient was worse. The pain in the left chest was more severe, resembling that of pleurisy; the pulse was full and frequent; the tongue brown, and rather dry; there was very little cough and no expectoration. On percussion, the right side was very dull over the lower lobe, less so over the upper lobe. The respiratory murmurs were nearly if not quite normal, over the whole of the right lung. Examination by auscultation unsatisfactory, on account of the turbulent action of the heart, and the catching character of the respiration. There were no cephalic or nervous symptoms. On Oct. 20th, the patient appeared more comfortable in the early part of the day, the respiration less laboured, and the pulse more quiet, and the tongue more moist; towards the latter part of the day, however, the symptoms increased in severity. Great dulness over whole of left side of chest was noticed, and greatly diminished resonance on the right side. The vesicular murmur was heard over a small portion of the superior lobe of the left lung only. Moist friction sounds over nearly the whole of the left lung could be heard, together with bronchial respiration, and, at some circumscribed parts, a very coarse crepitation. On the right side the vesicular murmur was rather faint, and greatly obscured by bronchial respiration. On Oct. 21st, there was less pain and dyspnœa, very little cough, with a soft infrequent pulse, pale countenance, and increasing dulness on percussion over the right side. Towards the latter part of the day there was less drowsiness. The patient died at 8½ o'clock, on Oct. 22d. He was perfectly sensible and rational within ten minutes of his death. A *post-mortem* examination was made three hours afterwards. Cadaveric rigidity was strongly marked: the skin of the chest and face was of a deeply jaundiced hue. On making an opening into the chest, about twenty ounces of yellow serum were found in the left pleura, none in the right. The pleural cavities of both sides, but particularly the left, were covered to a considerable extent with coagulable lymph of considerable firmness. The left costal and pulmonary pleuræ were bound strongly together by broad, thick bands, the result of some former disease. There were also a few much less firm attachments on the right side. The lower lobe of the left lung was in a state of gray hepatization, the upper lobe in that of red hepatization, and in both, at various points, were found circumscribed deposits of pus, containing from one-half a drachm to a drachm each. The lower lobe of the right lung was in a state of red hepatization, and the middle and upper lobes were greatly congested. In the lower lobe were found two or three purulent deposits, which appeared to form centres of inflammation, or metastatic foci. The wound along the scalp appeared as during life. Pus was found along the coronal and sagittal sutures, throughout the whole extent, dissecting the scalp from the bone to the breadth of one inch. The skull was roughened, and deprived of pericranium to that extent. The portion of the bone which had originally been denuded had begun to exfoliate, a line of separation being visible around it. On removing the calvaria, a thin layer of pus was found between the bone and dura mater, extending along the sagittal and coronal sutures to the same extent as on the external surface, the amount of pus within the skull being less than one drachm. There was a narrow strip of the dura mater each side of these sutures which was inflamed ; at other parts this membrane was healthy. The arachnoid and pia mater were perfectly normal. The brain and its ventricles, the cerebellum, medulla oblongata, and roots of all the cerebral nerves, were carefully examined, and no lesions were discovered. The heart and its valves, the vena cava, and azygos, the pulmonary veins and arteries, the jugulars, and the bloodvessels of the brain, were in a normal condition. The liver was apparently healthy.

Comments.—This man died of acute pyæmia resulting from gunshot contusion of the cranial vault, four days after the appearance of that disorder, and twenty-two days after his wound was inflicted. The foregoing report of his case is very interesting and instructive; it is also very complete in every essential particular, excepting two or three, namely, the anatomical appearances which the bruised portion of the skull itself presented on examination after death, and the condition of the veins of the diploë proceeding from the injured part in respect to their containing coagula, etc. The bruised portion of skull is described as being three inches long and one inch wide, as being denuded of pericranium and bathed in pus exteriorly, as being denuded of dura mater and bathed in pus interiorly, also as being roughened exteriorly, and in a state of incipient necrosis. The condition of the diploë, however, was not inquired into, probably because this part of the examination was inadvertently overlooked. The site of the contusion was high up on the cranial vault, and therefore it was not crossed by the incision made with the saw for the purpose of taking off the skull-cap. A special incision should have been made into the bruised portion of cranium for the purpose of exposing its interior to view. We know, however, from what has been found in strictly analogous cases, that the medullary tissue belonging to the injured part was also involved in suppurative inflammation, and that the cancelli of the diploë were filled with purulent matter. Both the outer and inner table could not have been simultaneously involved in destructive inflammation, as they were in this case, without there being also suppurative inflammation in the corresponding portion of diploë. As happened in the last five cases, so also in this instance, the stroke of the missile on the skull most probably aroused inflammation of a suppurative character in the medullary tissue underneath the place of impact, which afterwards spread from that tissue to the adjoining tables of the skull.

Prerequisite to the occurrence of pyæmia in any case whatever, is the existence of some local suppuration or some collection of purulent matter; for pyæmia never presents itself as an idiopathic or primary affection, but always as the sequel of some local suppurative inflammation, traumatic in respect to origin, with some very rare exceptions. But traumatic pyæmia is met with much more frequently when certain tissues are wounded than it is when other tissues are the seat of injury. Thus, every surgeon who had much to do with the treatment of wounds and operations in the late war must have noticed how seldom traumatic pyæmia supervened unless the bone was injured. Indeed, I have heard it stated by surgeons of large experience in our military hospitals, that they had never seen a case of traumatic pyæmia which was unconnected with lesion of the osseous tissue. This fact alone shows that in a very large majority of instances traumatic pyæmia results from injury of bone. On this point Mr. Simon says: "Not all surgical patients having wounds have an equal or nearly an equal liability to it. It shows an almost infinite preference for cases where bone structure (particularly cancellous bone structure) has been injured, as in compound fracture or in the surgical procedures of amputation and resection, and all the more, perhaps, in proportion as the injured bone is large." (*Sixth Report of Medical Officer to Privy Council*, p. 61.) We therefore have good reason to believe that, in the case just related, pyæmia resulted from injury, in the form of contusion, of the diploë, and that the local suppurative inflammation from which it directly sprung had its seat in the soft medullary tissue of the diploë, *i. e.*, it was in reality cranial osteo-myelitis of a suppurative character, the product of gunshot contusion of the skull which led to the occurrence of pyæmia in this case.

Perhaps the site of the contused and inflamed portion of skull aided somewhat in the production of pyæmia in the foregoing case, inasmuch as it lay directly over and along the course of the superior longitudinal sinus. It is but fair to suppose that absorption of the pyæmic poison would occur rather more readily from a purulent collection situated in close relation to the great venous canals of the dura mater than it would from a purulent collection situated at some distance away. Moreover, it is not improbable that if the veins of the diploë had been examined at the autopsy, some of those connected with the contused portion of cranium would have been found to be filled with blood clots undergoing puriform transformation, or, in other words, undergoing the process of thrombosis, and thus furnishing the venous emboli which produced pulmonary infarction, etc. The absence of cough, notwithstanding the severity and extent of the secondary lesion of the lungs, and the hebetude, which were noted in this case, the writer has also observed in many similar cases of acute traumatic pyæmia.

The reports published in the *Medical and Surgical History of the War of the Rebellion*, Part First, vol. ii. pp. 84, 85, "specify five cases of gunshot wounds of the scalp in which pyæmia supervened." One of these five cases was that which has just been related, and which was obviously an example of gunshot contusion of the skull. There is also good reason to believe that the other four cases were, in reality, examples of gunshot contusions of the cranium instead of uncomplicated gunshot wounds of the scalp, and there is nothing in the published account of them which disproves the correctness of this opinion. Indeed, whenever pyæmia presents itself as a sequel to seemingly uncomplicated wounds of the scalp, there is good reason, at least to suspect, that the underlying bone has also been injured, and that its medullary tissue is undergoing suppurative inflammation, whereby it becomes the fountain from which the pyæmic phenomena flow.

The next case belongs to the same category as the last. In it also gunshot contusion of the skull led to the occurrence of pyæmia in an acute form, which resulted in death.

CASE XIX.—G. Brower, sergeant, Co. F, 16th Ohio Vols., received at the siege of Vicksburg, Miss., December 28, 1862, a gunshot wound of the scalp, in the right occipital region, with contusion of the bone. He was conveyed to Paducah, Ky., on the hospital steamer City of Memphis, and admitted on January 13th into the St. Mark's Hospital. There was paralysis of the left leg; pyæmia supervened, and death took place February 21, 1863. (*Loc. cit.*, p. 122.)

CASE XX. *Chronic Pyæmia resulting from Gunshot Contusion of Right Parietal Bone; Death forty-five days after the Wound was inflicted; Autopsy; Injured portion of Bone extensively denuded, porous, and spongy; Meninges very much thickened and blackened.*—Thomas Kennedy, private, Co. M, 1st Mass. Heavy Artillery, aged 30, was wounded at Petersburg, Va., June 16, 1864, by a conoidal-pistol ball, which contused the right parietal bone near the descending branch of the lambdoidal suture. On the 21st he was admitted to the Lincoln Hospital at Washington. Simple dressings were applied, as the injury was considered slight. On July 16th he was furloughed, but he returned on the 29th, stating that while absent he had suffered from ague, and, for the last ten days had had a chill daily. A careful examination of the wound was now made, and a roughness of the external table of the skull was detected. He was much prostrated, but complained of no pain or uneasiness about the head. His pulse was frequent and feeble, tongue dry and red, and the abdomen tympanitic and painful. Three grains of calomel with one-fourth of a grain of opium were ordered every three hours, until the third dose had been taken; meantime tonics and stimulants were given, and afterwards continued in liberal doses. Sinapisms were applied to the epigastrium and extremities. No perceptible improvement, however, was obtained. He died on the afternoon of the 31st, remaining fully sensible, and able to answer questions intelligently until within two or three hours of death.

At the *autopsy* the seat of injury was found to be near the middle of the posterior edge of the right parietal bone. The missile had glanced downward and forward, and was found lying against the skull, two inches from the point of injury. The pericranium was separated a distance of three and three-quarter inches along the track of the missile; the denuded bone was porous and spongy. The line of separation from healthy bone was well marked. Upon removing the skullcap a slight sponginess of the internal table beneath the point of impact was observed. The meninges, for some distance around the seat of injury, were very much thickened and blackened, and firmly adherent to the calvaria. The brain-substance was softened, and the vessels very much congested. The heart, liver, and spleen were flabby. (*Loc. cit.*, p. 111.)

Comments.—The diagnosis of chronic pyæmia in this case is founded mainly on the symptoms which were observed during life, interpreted of course by the lesions which were revealed at the autopsy. They clearly show that death did not result directly from inflammation of the bruised portion of skull, nor from inflammation of the membranes of the brain, nor from inflammation of the substance of the brain. The cerebral softening found at the autopsy was not the red or inflammatory kind of softening, but appears to have resulted from impaired nutrition, and to have been brought about in the same way as the flabby condition of the heart, the liver, and the spleen, that were also found at the autopsy. The congestion of the cerebral veins was probably due to the mode of death. Moreover, the morbid state of the heart, liver, spleen, and brain, just described, denotes that the disease which killed this patient had also greatly impaired the nourishing qualities of the blood, *i. e.*, it had made important changes in the composition of the blood, and was therefore a general or constitutional disease most probably of zymotic origin. It was not typhoid fever, because neither the phenomena during life nor the *post-mortem* lesions which characterize that disease were found. It was not ague, nor intermittent, nor remittent paludal fever, because in these days of the liberal use of quinia paludal fevers do not destroy life in the way this man's life was destroyed; and the enlarged spleen and bronzed liver of malarial disease also were not present. This man, then, must have died of septic blood-poisoning in the form of pyæmia, which ran a chronic course, for he survived the pyæmic invasion twelve days. The pyæmic poison got into the general circulation by absorption from the suppurating diploë of the injured portion of skull. His chills were not malarial but pyæmic, in respect to causation. Moreover, pyæmic rigors have not unfrequently been observed to present themselves with considerable regularity, as they did in this case, and thus have readily been mistaken for malarial rigors. The rapidly increasing debility, the great prostration of strength, the frequent and feeble pulse, the dry tongue, the tympanitic and tender belly, associated with but little if any disturbance of the intellect, until death is near, form a combination of symptoms often witnessed in cases of pyæmia; but in no other disorder. The absence, however, of secondary abscesses of the lungs, liver, etc., is noteworthy; but this is to be said concerning it, namely, that such abscesses are not present in those cases of undoubted pyæmia which eventuate in recovery, and that the formation of such secondary abscesses is not essential to the constitution of the disease. Of fifty-nine cases of undoubted pyæmia treated in the Stanton Military General Hospital during the year ending Sept. 30, 1864, under the writer's direction, fifty-six died and three recovered. Moreover, secondary abscesses in the lungs, liver, etc., are sometimes wanting in those cases of pyæmia where large metastatic abscesses form among the muscles of the extremities.

In regard to the frequency with which pyæmia proves to be the proximate cause of death in cases of gunshot contusion of the cranial bones, theoretical considerations would lead to the belief that purulent infection would be common in gunshot contusions of the skull, in consequence of the entrance of the pyæmic contagium into the veins of the diploë, but the surgical reports of the late war do not sustain the supposition, and present not more than half a dozen cases belonging to this category among the fifty-five deaths which occurred in three hundred and twenty-eight patients with gunshot contusions of the cranial bones whose cases were reported. Pyæmia, however, presents itself with sufficient frequency among the consequences of cranial contusions, and that too in a fatal form, as to make it the duty of the surgeon to do everything he can to prevent its occurrence.

3. *Inflammatory Necrosis with Exfoliation, and Caries, as results of Cranial Contusion.*—Necrotic ostitis attended with exfoliation of the dead piece of bone very often results from contusion of the cranial bones, in cases where, for various reasons, it cannot be satisfactorily determined whether the ostitis itself is a primary affection, or whether it is a secondary affection, and has been induced by traumatic inflammation of the medullary tissue of the diploë, on the one hand, or by traumatic inflammation of the pericranium on the other. These cases of traumatic ostitis, then, whose causal relations and real character are vague and undetermined, we propose to group together under the head of inflammatory necrosis, a term which defines sufficiently well the nature of its origin without attempting to state whether the osseous inflammation has resulted from cranial osteo-myelitis, or from cranial periostitis, or whether it is a primary affection of the bone-tissue itself. But primary ostitis in an acute form, by which is meant acute inflammation commencing in the bone-cells and calcified intercellular substance of the osseous tissue, is a disease which is but very rarely met with; while acute medullitis and periostitis, but especially the former, not unfrequently present themselves as primary disorders, resulting from injury. Nor are we surprised at this comparative rarity of acute primary ostitis, when we remember how exceedingly vascular and rich in cell-structures the medullary tissue is; while the osseous

tissue proper is among the least vascular of all the tissues of the body, and at the same time is but scantily supplied with corpuscular elements. Ollier, who is very high authority on this subject, says: "Inflammation does not affect the bone-cells proper, except secondarily; its first effects are produced upon the marrow-cells, the osteogenetic layer of the periosteum, and the contents of the Haversian canals." (*American Journal of the Medical Sciences*, January, 1868, p. 152.) However, putting to one side the question as to whether traumatic ostitis ever presents itself as a primary disorder of bone, it is certain that it very often presents itself as a secondary disorder, having for its proximate cause inflammation of the medullary tissue or of the periosteum; and, as a secondary disorder of contused bone, it may run an acute, a subacute, or a chronic course. In the acute and subacute forms of traumatic ostitis suppuration is present, and necrosis of the injured portion of bone is very apt to occur from stoppage of the circulation of blood therein through mechanical pressure exerted by the products of the inflammation, especially by the repeated division and multiplication of the cells thereof upon the capillaries within the unyielding walls of the Haversian canals, etc. Thus the inflow of nutrient blood and of nutrient *materiel* in every form is arrested, and the affected portion of bone perishes, or becomes necrosed, in consequence of such stoppage of nutrition. After some time the dead bone gets separated from the living or sequestrated by demarcation or fungating ostitis; and ultimately, in favourable cases, it may be expelled as an exfoliation or a sequestrum. As soon, however, as the necrosed bone is detached from the living it is usually extracted by the surgeon's art.

The next three cases are examples of inflammatory necrosis and exfoliation of parts of the cranium, occurring in consequence of gunshot contusions of the skull.

CASE XXI.—Benjamin Stafford, private, Co. I, 26th N. Y. Vols., was admitted to the Fairfax Seminary Hospital, Sept. 29, 1862, with a gunshot wound over the right side of the frontal bone, received at Antietam, on Sept. 17th. He was returned to duty May 8th, 1863. It was found, however, that the outer table of the os frontis was exfoliating, and the man was discharged from the service on May 28, 1863. He was examined at Utica, N. Y., for a pension, by Dr. H. B. Day, April 22, 1864. It was found that two fragments of bone had exfoliated, and that there was a fistulous sinus through which detached bone could still be felt. (*Loc. cit.*, p. 104.)

CASE XXII.—James H. G., private, Co. A, 90th Penna. Vols. Supposed gunshot scalp-wound over occipital, Antietam, Sept. 17, 1862. Entered hospital at Washington, Sept. 23d. Transferred to Fort Schuyler's Hospital, N. Y., October 7th. Transferred to Fort Hamilton, Dec. 1st. On Dec. 13th, he entered the Satterlee Hospital, Philadelphia, complaining of pain in the occipital region. The wound was closed, but it reopened on Dec. 18th. On January 18, 1863, a circular portion of dead bone, an inch in diameter, was detected by a probe. The patient had no pain or derangement of the mental faculties, and walked actively about the ward. About Feb. 2d, the discharge from the wound was profuse, and the necrosed bone had not separated. There was no change in his condition until Feb. 25th, when the exfoliation was observed to be loose, and it was extracted through a crucial incision. The exfoliation consisted of a portion of the external table, an inch in diameter, and several smaller pieces. On March 3d yet another piece of the external table was removed. On March 17th the wound was nearly healed. The patient felt entirely well, and on May 22, 1863, he was discharged from the service. He appears to have had no subsequent trouble, since his name does not appear on the list of applicants for pensions. (*Loc. cit.*, p. 103.)

CASE XXIII.—Francis W. Gilkey, Co. K, 10th Penna. Reserves, was wounded in one of the earlier battles of the war, and made a prisoner. In January, 1863, he was exchanged, and received at the Annapolis General Hospital. He had to the right of the vertex a large ulcer, resulting from a gunshot wound of the scalp, extending over the sagittal suture. The skull was necrosed, and probably there had been denudation, with contusion of the bone. Erysipelas supervened, followed by gangrene. When this was arrested exfoliation took place, and the brain was exposed. A necrosed fragment of the parietals, irregularly triangular in shape, two inches long by one inch wide, and embracing both tables, was removed. Granulations sprang up, the wound closed, and the patient recovered without any further complications. He was discharged from the service on January 29, 1863. His name does not appear on the pension roll. The specimen is preserved in the Army Medical Museum. A figure of it is given in the *Medical and Surgical History of the War*, Part First, vol. ii. p. 105.

Comments.—The last case is chiefly remarkable for the large size of the exfoliated piece of bone. It was two inches long by one inch wide, and embraced both tables of the skull. If it were profitable so to do many additional examples of inflammatory necrosis and exfoliation of the cranial bones resulting from gunshot contusion might be adduced from the *Medical and Surgical History of the War of the Rebellion;* since exfoliation was frequently observed in gunshot contusions of the skull, and many examples of it are noticed in the categories of other complications.

With regard to *Caries* as a result of contusions of the cranial bones, the experience of our civil war shows that it but seldom occurs, inasmuch as it was met with in but four of the reported cases. Dr. Otis, the accomplished surgical historiographer, says: "Gunshot contusions of the cranial bones were succeeded, in three instances, by caries. This complication, common enough in tertiary syphilis, mercurio-syphilis, and scrofula, rarely occurs as a result of injury, unless there is some constitutional taint. There is no evidence, however, that any such vice of system existed in the cases of which abstracts are subjoined. The energetic treatment advised by authors, such as applications of the rugine or trepan, the actual cautery, or chloride of zinc, red oxide of mercury, and other potent escharotics were not employed in any of these cases." (*Loc. cit.*, p. 106.)

Next we present a brief account of one of these cases.

CASE XXIV.—Wm. Price, Co. H, 8th Tennessee Infantry, aged 39, received in the engagement near Atlanta, Ga., Aug. 8, 1864, a slight injury of the left parietal bone, and also a flesh wound of the leg. He was taken to the field hospital of the 23d Corps, and on Aug. 15th was admitted to the Asylum Hospital, Knoxville, Tenn. No account of his treatment is recorded. He was discharged from the service on June 20, 1865, and pensioned from that date. On March 1, 1869, pension examining surgeon, R. P. Mitchell, reports that this man was living at Rogersville, Hawkins Co., Tenn.; that he had caries of the skull, bits of bone passing out in the purulent discharge. The wound was still open and suppurating five years subsequent to the injury, and the man was utterly unable to perform manual labour, or to bear exposure to the sun's rays. (*Loc. cit.*, p. 106.)

4. *Inflammation of the Pericranium as a consequence of Contusions of the Skull.*—The experience of our army surgeons during the late war of the rebellion has abundantly shown that cranial periostitis should not be classed among those consequences of cranial contusion which are frequently met with; for protracted inflammation of the bruised pericranium was observed in only a few instances, from the beginning to the end of the conflict. Thus in the *Medical and Surgical History of the War* out of three hundred and twenty-eight cases of gunshot contusions of the cranial bones, only four examples of periostitis of the skull are reported; and not a single instance is given wherein the osteogenetic layer of the pericranium was roused to functional activity by inflammatory excitement, so as to form new laminæ of osseous tissue. Moreover, Dr. Otis states that he has carefully examined more than forty crania, contused by gunshot projectiles, without finding even one example of the local hyperostosis of the skull which would have resulted from inflammation of the pericranium, had it really been present. (*Loc. cit.*, p. 127.)

The following is one of the few instances of cranial periostitis that were reported:—

CASE XXV.—Charles Harrick, private, Co. D, 94th N. Y. Vols., aged 25, received at Gettysburg, July 3, 1863, a contusion of the right parietal bone at the lower posterior angle, by a conoidal musket-ball, which lodged under the integuments. He was admitted to Satterlee Hospital, Philadelphia, on July 10th, and on the following day the position of the ball was detected by a probe, and the missile was extracted. A slight scale of the outer table necrosed, and the *pericranium was inflamed for a while*; but the wound ultimately did well, and the soldier was returned to duty Dec. 3, 1863. (*Loc. cit.*, p. 102.) His name is not found on the pension list.

Comments.—This example of cranial periostitis occasioned by the impact of a conoidal musket-ball and the irritation due to its remaining in contact with the torn and bruised pericranium, one whole week, before its extraction, serves well to illustrate the kind of inflammation that is kindled in the pericranial membrane of healthy subjects, when badly injured by the impact of, and afterward irritated by contact with, gunshot missiles. Moderate suppuration, and the exfoliation of a slight scale of the outer table occur, then the wound heals, and afterwards the cure remains complete, which is proved by the fact that the man never applies for a pension. And this, too, is all that happens in an exceptionally bad case of traumatic inflammation of the pericranium; for, in the great mass of strictly analogous cases of gunshot contusion of the head, the pericranium gives no trouble whatever.

This example of cranial peritonitis, occasioned by contusion, also shows how small the destructive power really is, which traumatic inflammation of the pericranium can exert upon the contiguous table of the skull. And we are not surprised to find it so, when we consider how small a share the pericranium has in supplying the blood which nourishes the cranial bones; for the skull receives almost all its nutrient blood from vessels which run along the grooves between the dura mater and the inner table, or pass through the tunnel-like canals in the spongy structure of the diploë. The portion which it receives from the vessels of the pericranium is relatively very small. Even the external table gets almost all its nourishment from the walls of the diploë. Hence, it happens that the pericranium can be extensively torn off from the skull, and can be otherwise widely destroyed, by violence or by disease, without the occurrence of any corresponding lesion whatever of the denuded bone. The writer has seen a considerable number of cases wherein some bone was extensively deprived of periosteum, and yet no caries, nor necrosis, nor any morbid change whatever took place. The bones in which he has seen this occurrence were those of the cranium, the face, the thigh, and the leg. T. Holmes bears concurrent testimony. He says: "It is true that large separations, and even extensive destructions, of the periosteum may occur without the death of any portion of the bone, and this is indeed common in the bones of the head and face; but the peculiar circulation in the former, and the great vascularity of all parts in the latter region sufficiently explain this fact." (*System of Surgery*, vol. iii. p. 762.) The following case bears considerable resemblance to the last in several important particulars:—

CASE XXVI.—George D. King, private, Co. I, 21st Mich. Vols., was wounded at the battle of Stone River, Dec. 31, 1862, by a musket ball, which struck behind the left ear and lodged under the scalp, lying against the bone. He was sent to Hospital No. 7, Louisville, Ky. On January 15, 1863, erysipelas supervened. He gradually recovered, and, on April 15th, he was transferred to Hospital No. 19. On the 27th, he was readmitted to Hospital No. 7. Four months after the reception of the injury the ball was extracted. The sense of hearing was entirely destroyed. He was discharged from the service for disability, rated at one-half, on May 16, 1863. A year subsequently, pension-examining surgeon Geo. W. Mears reports that the wound was still discharging slightly. There was probably a scale of the outer table detached. (*Loc. cit.*, pp. 101, 102.)

Comments.—This man received a gunshot contusion of the skull; and the musket ball which occasioned it remained unextracted for a period of four months. It is not improbable that cranial periostitis of a pretty severe character occurred in consequence thereof. Fifteen days after the wound was inflicted erysipelas supervened. It is also not improbable that the pericranial inflammation had a good deal to do in causing the erysipelatous inflammation. It is worthy of special remark in this connection, that *no case of diffuse inflammation of the pericranium was reported during the whole course of the war.*

5. *Meningitis and Encephalitis as consequences of Contusions of the Cranial Bones.*—These formidable disorders were the most common of all the proximate causes of death after gunshot contusions of the cranium, during the late civil war. Out of 328 cases of that form of injury which were reported, 55 patients died; and, in 32, or considerably more than one-half of the fatal cases, "various secondary lesions"—of the brain and its membranes, inflammatory in their nature, were the proximate causes of death. (*Med. and Surg. Hist. of the War of the Rebellion*, Part First, vol. ii. p. 126.) These truly formidable disorders, then, must be ranked among the most important of all the consequences with which gunshot contusions of the skull are attended. Now, we have already presented a considerable number of cases wherein contusions of the skull proved fatal through the spreading of the inflammatory process from the bruised portion of skull to the contiguous membranes and substance of the brain. For the purpose of impressing the reader still more strongly with the great frequency, variety, and importance of this complication, the following examples are added.

CASE XXVII. *Gunshot Contusion of Frontal Bone; Necrotic Ostitis supervened; Meningitis followed; Death twenty-seven days after the wounding; Autopsy.*—Private A. H. Cutting, Co. K, 13th Massachusetts Vols., was wounded at the battle of Gettysburg July 3, 1863, by a conoidal musket-ball, which caused a contusion of the frontal bone, just above and external to the right frontal eminence. He was admitted to Camp Letterman, and thence was sent to the McDougall Hospital, at New York, on July 12th. Meningitis supervened and death ensued, on July 30th, twenty-seven days from the reception of the injury. The osteological specimen is preserved in the Army Medical Museum, at Washington. The injured part of the external table is porous and spongy, and a small scale of bone was evidently in process of exfoliation. The internal table shows no trace of injury beyond the most trivial discoloration. (*Loc. cit.*, pp. 110, 111.) In this case the gunshot contusion obviously gave rise to necrotic ostitis of the bruised part of the frontal bone, which, in turn, occasioned meningitis that proved fatal.

The following is an example of secondary meningo-cerebritis the result of cranial contusion and inflammation, wherein trephining was resorted to but without success.

CASE XXVIII.—Private S. D. Chapman, Co. H, 92d Ohio Volunteers, received at the battle of Chickamauga, Sept. 23, 1863, a gunshot wound of the scalp, near the upper posterior angle of the right parietal, with contusion of the bone. He was sent to Nashville, and admitted to Cumberland Hospital, on the 25th. The wound produced little inconvenience until October 4th, when grave head symptoms, such as delirium and convulsions, supervened. There was hemiplegia also. On Oct. 5th, the patient was comatose, and trephining was resorted to. When the skull was perforated, exit was given to a quantity of pus, which had formed between the dura mater and cranium. Consciousness was restored almost immediately, and apparent steady improvement for the next twenty-four hours; but symptoms of compression then recurred, and the patient died on Oct. 9th, sixteen days after the wound was inflicted. At the *autopsy* the right hemisphere was found partially disorganized, and covered with a layer of pus which extended to the longitudinal fissure. (*Ibid.*, p. 124.)

The next case is an example of secondary meningitis and abscess of cerebellum, the result of cranial contusion and inflammation; trephining was also resorted to without success.

CASE XXIX.—Benjamin F. Chappel, sergeant, Co. H, 8th N. Y. Cavalry, aged 27, was wounded before Petersburg, Va., April 1st, 1865, by a pistol ball which entered one inch above and one and a half inches to the left of the occipital protuberance, and emerged just below it on the opposite side, denuding the bone of pericranium. He was admitted to the 3d division hospital of the Cavalry Corps, and, on the 3d, was sent to Washington, where he entered Harewood Hospital on the 5th. Until the 14th, the patient seemed to be improving, but on that day a slight hemorrhage from the occipital artery occurred, causing the loss of about six ounces of arterial blood. The hemorrhage was arrested by compression, and the case apparently progressed favourably. On the evening of the 18th, the patient, however, complained of considerable pain in the region of the cerebellum. On the following day considerable gastric irritation manifested itself, and, at intervals, there was slight delirium. Ether was administered, an incision two and a half inches in length was made, just below and parallel to the lambdoidal suture, the scalp was retracted, the trephine applied, and a disk of bone removed, giving exit to a quantity of pus. The patient reacted promptly after the operation, and seemed to be much relieved, but in the evening he began to sink, and died on the morning of April 21st, twenty days after the wound was inflicted. The *autopsy* revealed a large abscess in the left lobe of the cerebellum, which contained four or five ounces of pus. The medulla oblongata was implicated. The osteological specimen is preserved in the Army Medical Museum at Washington. The bruised portion of bone is slightly discoloured and cribriform (*Ibid.*, pp. 124, 125), *i. e.*, it exhibits the traces of osseous inflammation.

But in one of the instances of cranial contusion from gunshot related above (see Case XIV.) where the trephine was also applied to relieve the symptoms of cerebral compression no pus was found between the skull and dura mater, and no signs whatever of secondary meningitis. There was, however, a large abscess in the left cerebral hemisphere, whose contents were discharged by puncturing the brain-substance through the trephine-hole with a bistoury. This abscess, obviously, was not produced by spreading of the inflammatory process from the bruised skull to the membranes and substance of the brain. It was doubtless due to injury of the brain-tissue itself in the form of concussion, commotion, or contusion thereof, produced by the same blow that bruised the skull. The cerebral abscess, and the inflammatory necrosis were independent affections which simultaneously resulted from the operation of the same cause. In another case belonging to the category of gunshot contusions of the skull, that of Col. Farnham (*loc. cit.*, pp. 109, 110) the stroke of the missile upon the left parietal contused the pia mater and brain-substance, with ecchymosis thereof, beneath the place of impact, and thus led to the formation of a cerebral abscess, while there were no evidences of inflammatory disorder in the cranial walls; and it often happens in cases of cranial contusion that the patient suffers much more from the mechanical injury which the brain-substance sustains thereby, than from the bruising of the bone.

To the last-named category, *i. e.*, to concurrent injury of the brain, rather than to injury of the skull, belong the numerous cases of *persistent headache*, *vertigo*, *disordered vision*, *deafness*, *chronic irritability of the brain*, *epilepsy*, *aphasia*, *paralysis*, and *mental aberration*, which were observed in the persons of those who sustained gunshot contusions of the cranium during the late civil war, amounting in all to 104, out of 328 reported cases of that form of injury. (*Loc. cit.*, pp. 113–121.)

Treatment of Contusions of the Cranial Bones.—The plan of treatment which should be followed in cases of injury of the head, when there is reason to believe that the skull is bruised, whether it be from the stroke of bullets, or from blows or kicks or falls on the head, or from any other cause whatever, requires first of all the procurement of corporal and mental rest as nearly absolute as practicable under the circumstances which surround the patient. He should be confined to bed in a sitting or semi-recumbent posture with his head comfortably supported in this elevated position, and all noises or loud sounds, and other cerebral excitants of every kind, should be carefully excluded; in short, everything that is possible should be done to secure quietude of the body as a whole, and quietude of the brain, since *rest* is Nature's almost universal remedy.

The following example illustrates some of the bad effects of inattention to this most important precept:—

CASE XXX.—Charles K. Baker, private, Co. D, 27th Mass. Vols., aged 25, was wounded at the battle of Newberne, N. C., March 14, 1862, by a conoidal musket-ball, which made a long furrowed wound of the right parietal region, lacerating the scalp and denuding the pericranium. He was treated at a field hospital by his regimental surgeon. The right side of the head was shaven, and a compress dipped in cold water was secured over the wound by a bandage. The patient was required to keep his bed in the log hut used as an hospital, and to observe a strict diet. He had no headache, nor any symptom of disturbance of the brain. Careful exploration revealed no injury of the bone. On March 20th the wound was fairly cicatrizing, and the patient was sent on an hospital transport up the Neuse River to the Carver Street Hospital at Newberne, five miles distant. Two days subsequently, through the inadvertence of an hospital steward, this man's name was placed in the list of wounded to be sent northward on the hospital steamer New York. Surgeon J. B. Upham, in charge thereof, reports that he had no cerebral symptoms on the passage. He proceeded to his home in Amherst, Mass. On April 3d he complained of headache, and on the next day symptoms of compression of the brain appeared. On April 7th he was trephined, and died a few hours after the operation. (*Loc. cit.*, p. 124.)

No doubt this man's chances of recovery were greatly lessened by removing him from the hospital wherein he was first placed; and we may with propriety here remark in a general way, that the practice of transferring patients belonging to this category from hospital to hospital, prior to recovery, which obtained during our war of the Rebellion, as shown by the record of many cases related in the foregoing pages, was highly detrimental to most of these patients, and, in all probability, occasioned the loss of some lives which might otherwise have been saved.

Besides rest of body and mind, the patient's diet should be rather spare, and restricted to articles that are nutritious and of easy digestion, but not stimulating in their nature.

The ice-bag should be applied to the bruised part for the purpose of keeping down the inflammatory process therein; *i. e.*, in order to prevent its becoming suppurative and necrotic, on the one hand, and to protect the membranes and substances of the brain from its invasion, on the other. The ice-bag should be constantly kept on the injured part, both day and night, until all danger has been passed; and compresses should be interposed between the ice-bag and the scalp of sufficient thickness to prevent discomfort. In cases where pyrexia, headache, and other symptoms of meningo-cerebral inflammation appear, aconite in full doses and mercurial purges can be administered with advantage; and in sthenic cases blood can be drawn locally by leeches or cups, with decided benefit. Symptoms of cerebral compression, when due to the exudation of serum, can be combated by blistering the neck, by hydragogue cathartics, and by exhibiting potassium iodide in ten-grain doses every four hours. But for the purpose of controlling cerebral inflammation, the judicious and methodical application of the ice-bag to the head is of more value than all the other remedies put together. Such, at least, is the lesson which my own experience has taught.

When erysipelas of the scalp supervenes, it should be treated with a strong solution of sodium sulphite externally, and with liberal doses of the sesquichloride of iron and muriate of quinia internally; in bad cases a liberal use of alcoholics should also be made. Fortunately, this complication is of very infrequent occurrence, for but six cases of it are reported among the 328 patients having gunshot contusions of the cranial bones that were observed during our war of the Rebellion (*loc. cit.*, p. 101). When abscesses form beneath the scalp, their contents should be withdrawn at an early period by suitable incisions, followed by poultices. Large cuts should not be made when smaller ones will answer the purpose, because of the vascularity of the scalp and the risk of hemorrhage. The "puffy tumour" of Pott should also be opened at an early period. Concerning this kind of swelling, that sagacious observer remarks: "The inflammation of the dura mater and the formation of matter between it and the skull, in consequence of contusion, is generally indicated and preceded by one [symptom] which I have hardly ever known to fail. I mean a puffy, circumscribed, indolent tumour of the scalp and a spontaneous separation of the pericranium from the skull under such tumour." (Pott's *Chirurg. Works*, vol. i. p. 56.) The surgical history of our war of the Rebellion, however, shows that this form of abscess is by no means of frequent occurrence, since it presented itself in but few of the 328 cases above mentioned. Exfoliations and sequestra should always be extracted as soon as they are completely detached.

Trephining in cases of cranial contusion for intra-cranial abscess was, in Pott's hands, a very successful operation, for by this means he saved five out of eight cases (*op. cit.*, pp. 63–107). But no such success has attended the practice of other surgeons. During our war of the Rebellion, trephining was resorted to for cerebral compression in twelve cases of gunshot contusions of the skull, but without success in every instance. In five of them pus was found between the skull and dura mater, in one case beneath the dura mater, and in two cases in the substance of the brain. In two instances it is alleged that intra-cranial extravasation of blood was found; in four that extensive arachnitis and meningitis were present; in four cases, however, the causes of the symptoms of cerebral compression were not specified (*loc. cit.*, pp. 123–126). Indeed, the successful issue of a case of trephining for intra-cranial abscess, the result of contusion of the skull, is almost unknown to the surgeons of the present day. And although this operation offers but small hope for the relief of cerebral compression when produced by purulent matter or other inflammatory products, the result of cranial contusion, it should not be entirely given up, since it affords the only chance left for saving such cases.

In very rare instances the purulent matter beneath the dura mater is walled in by plastic material in such a way that a perfectly circumscribed abscess is formed. In such instances, as soon as the skull is perforated the dura mater bulges into the trephine-hole; it is also tense and without pulsation. Here, there is no doubt as to what ought to be done. The dura mater should be punctured with a bistoury, and the matter evacuated. Thus, Guthrie saved one of his patients by incising the dura mater. (*Injuries of the Head*, p. 127.) In Roux's case, on withdrawing the trephine a large aperture was found in the dura mater, through which the contents of a circumscribed abscess within the cavity of the arachnoid rapidly escaped, and the patient recovered. (*Archiv. Général. de Méd.*, vol. xxiv. p. 268.) Mr. Dunville's case affords another striking instance of circumscribed suppuration beneath the dura mater, the result of cranial contusion.

The patient, a young girl, was admitted into the Manchester Royal Infirmary for a scalp-wound with denudation of the frontal bone. Three weeks after the injury, symptoms of cerebral compression appeared, and it was thought that a collection of matter had gathered between the dura mater and the skull at the seat of injury. Accordingly, the trephine was applied, but no pus was found on the dura mater. That membrane, however, was whiter and thicker than normal, excepting one point where there was a red spot, which proved to be a small aperture in the dura mater. Through it the flat end of a probe was passed, whereupon a quantitity of most offensive pus spirted out. This patient also ultimately got well (*British Med. Journal*, 1858, vol. ii. p. 743). As a *dernier ressort*, then, we should not hesitate to employ the operation of trephining in those cases of contusion of the skull where the symptoms of cerebral compression present themselves in consequence of intra-cranial suppuration, for by so doing we may occasionally rescue a patient from otherwise inevitable death.

In all cases of cranial contusion where suppuration of the diploë occurs, Abernethy strongly recommends that the matter should be discharged, promptly, by trephining the outer table, or, in other words, that abscess of a cranial bone should be treated on the same plan as abscess of any other bone. He says:—

> "When matter is formed in the diploë, the pericranium will certainly separate from the bone, and the external table of the skull will undoubtedly perish. In a case so clearly marked, the conduct to be pursued is obvious, which is to remove a portion of the external table with the trephine, so as to discharge the matter collected in the diploë, without which no relief can be obtained. I have seen in several cases, where the operation was performed early, that the external table came away within the circle of the trephine, the matter was discharged from the medullary part of the bone, and the internal table remained sound and entire, covering the dura mater. Granulations soon arose, and the patients got well, with the exfoliation only of a portion of the outer table. The mischievous consequences of delaying the operation, when once the disease is known, must be evident; for the matter collected within the bone, having no outlet, will press on every side, first gradually destroying the diploë, sometimes extending itself over almost the whole of the cranium, and at last occasioning the partial absorption of both tables, so that the skull after death shall be found perforated with a number of holes, like a piece of worm-eaten wood. These holes afford a discharge to the matter, which not only oozes out beneath the pericranium, but also insinuates itself between the skull and dura mater; till at length the patient sinks, worn out by the irritation and fever which this painful and extensive disease creates, unless, as it sometimes happens, he is previously destroyed by inflammation attacking the membranes of the brain." (*Surgical Observations*, vol. ii. pp. 68, 69, Am. ed. 1811.)

When, therefore, the surgeon finds on incising a "puffy" swelling, or any other swelling of the scalp, in a case of cranial contusion, that there is oozing of purulent matter from the external table of the skull, or when from any cause whatever he becomes satisfied that the diploë is suppurating, he should proceed without delay to expose the diseased bone by suitable incisions, and "to remove a portion of the external table with the trephine, so as to discharge the matter collected in the diploë, without which no relief can be obtained." This operative procedure should be supplemented with antiseptic dressings; and there is good reason to believe that this plan of treatment, especially when begun at the outset of the suppuration, would be attended with most gratifying results.

46 WASHINGTON SQUARE, July 7, 1879.

ARTICLE VII.

TWO CASES OF CLONIC BLEPHAROSPASMUS AS TRAUMATIC REFLEX NEUROSIS.

By F. C. HOTZ, M.D., Ophthalmic Surgeon to Illinois Charitable Eye and Ear Infirmary, Chicago, Ill.

THE convulsive action of the orbicularis palpebrarum, which causes the morbid nictitation of the eyelids, is generally due to reflex irritation. It may be excited by the irritation of a foreign body upon the conjunctiva or cornea; it may be caused by acute inflammations of the cornea or conjunctiva; it may be occasioned by the abnormal strain of the organs of accommodation.[1] In some cases the nictitation cannot be accounted for by any local anomaly; but, then, we may find as a remote cause a disorder of the digestive or uterine functions, or an anæmic or debilitated state of the constitution. Still there remains a number of cases of blepharospasmus which, until recently, seemed inexplicable by any apparent cause and were regarded as the result of a bad habit.[2] People take very easily to this idea of a bad habit as an explanation of morbid phenomena, and adhere to it very tenaciously, even though it has long been discarded by the advanced experience of medical science. Some thirty years ago it was an universally accepted doctrine that a child could acquire convergent strabismus by habit, by imitating a cross-eyed child, or by looking steadily at a ribbon or a curl of hair dangling close in front of its eyes. Thanks to the classical works of Von Graefe, Donders, and others, this idea has been thoroughly dispelled from the minds of medical men. But we find it still firmly rooted in the minds of the laity; and it will probably take another quarter of a century, before, at least, the educated class of the people will have abandoned the old idea, and will understand that the development of strabismus depends upon conditions of the eyes on which the will of the child has no influence.

Again, children are often observed breathing with the mouth open; they are scolded and punished for what is supposed to be a bad habit, when a careful examination discloses an obstruction of their nasal passages, due

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[1] See Chicago Med. Journal and Examiner, March, 1878.

[2] Mackenzie, Treatise on Diseases of the Eye, 1854.